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Tunings, scales and tonal systems in antiquity

Music need not employ pitches.[1] If it does, these need not stand in fixed relations (tunings). If they do, they need not be perceived as scales – and on the other hand, if there are scales, these need not imply a fixed tuning. Finally, if a particular music culture does use scales that implement more or less standardised intervals, these still need not be conceptualised as a tonal system. And yet, we find such conceptualised systems both in cuneiform and in Greek written sources.[2] In this contribution I am going to revisit these, with a focus on the extent to which these written expressions of musical matters are still tied to their original background in music-making, or have emancipated themselves as objects of reasoning for its own sake, in a development towards music theory. As the primary criterion for the latter case I regard the evolution of conceptions that are no longer of immediate use for a member of the music-producing classes (which include not only performers but also instrument makers). The distinction is not straightforward, since abstract ideas may well, secondarily, re-enter the domain of music-making; but I hope that with some caution the secondary element in such instances can be detected. In any case, I think past scholarship on ancient musics has rarely erred in the direction of attributing too much to the practitioner, especially the instrumental practitioner: rather, one was prepared to assume elaborate intellectual enterprises of the speculative sort on the part of the ancients, based perhaps on vocal melodies and suitable experiments.[3] It is against such a background that I will try to show how much of what we know about the 'tonal systems' of ancient Mesopotamia and Greece can (and should) be understood on the basis of direct experience with instruments that were common at the time, and how theory of a more abstract kind would have risen from there.

Possible origins of pitch-related concepts

Let us start from some general thoughts on music-related activities that are known to have been undertaken in the ancient Mesopotamian and Greek cultures, and which may have been involved in the formation of pitch-related concepts.

The most important are: the construction of instruments; processes of tuning; developing systems for pitch-related communication by means of language (including body language); the intellectual contemplation of certain elements of

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[1] I express my gratitude to Dahlia Shehata for sharing her thoughts on important points, and to Tosca Lynch for a lot of suggestions in the course of editing my style.

[2] The study of ancient Near Eastern music necessarily involves frequent reference to the Greek (and hence Hellenistic) world, of whose music so much more is known, and with which it doubtless shared many traits, be it by common inheritance or interaction.

[3] Cf. for instance the wholesale inclusion of ancient musical writings under the heading of "speculative traditions" in the Foucaultising structure of Christensen, Th., (ed.), *The Cambridge history of Western music theory*, (Cambridge 2002).

performed music; the investigation of pitch relations with the help of experimental instruments; and finally the quantification of musical structures by numerical means. Obviously the last items in this list belong to a stage of advanced reflection, without which music-making as such may function just as well. On the contrary, the first two are crucial ingredients of many musical cultures that make use of pitched instruments, and the third can be essential in passing on the respective skills from master to pupil. Correspondingly, we ought not to expect to find the origins of the more basic issues in the historical record: music is so much older than writing, and the same is very probably also true for almost all kinds of instruments in question. On the other hand, even with the utmost caution to avoid the pitfalls of progressivism, one cannot but recognise the development of new ways of analysing musical structures, which went hand in hand with philosophical debate about the nature and value of music, in the Greek world of especially the 5th and 4th centuries BC.[4]

The most direct way of conceptualising pitch structures is related to the tuning of instruments. Particularly important in this context are stringed instruments, since their pitches are comparatively easy to adjust, and because here the entire tuning process (in the case of lyres, harps, fretless lutes and lutes with movable frets) or a vital part of it (in the case of lutes with fixed frets) falls within the domain of the performer. Stringed instruments are also a priori likely to favour the development of standardised pitch relations between their individual strings. This is because strings – at least well-produced strings[5] – tuned to resonant intervals can enhance the instrument's sound by establishing an augmented oscillatory regime through sympathetic resonance, even if only one of the strings in a resonance-coupled group is set in motion by the player. This becomes especially clear from comparison with finger-hole-equipped wind instruments with a single duct such as flutes: here the individual playable notes do not interfere with each other, so that the presence or absence of resonant intervals between them does not influence their sound. Moreover, finding the location for finger holes from which resonant intervals can be produced without considerable effort is not at all a straightforward task. So it is no wonder if our earliest evidence for strings implies resonance-based tunings, while single-duct wind instruments in the archaeological record often expose arrangements of finger holes (especially equally spaced) that seem to preclude scales of a similar type. A special case, however, is represented by wind instruments of two or more ducts sounding simultaneously, such as the double reed-pipes,which were eminently important in ancient Greek music but also featured prominently in the Near East as well as in Egypt. Here it is a priori likely that different notes produced from the single pipes were meant to blend harmoniously, and Greek literary sources explicitly confirm the employment of

[4] Cf. Barker, A., *The science of harmonics in Classical Greece*, (Cambridge 2007).

[5] I.e., strings of uniform characteristics throughout, so that the actual harmonics produced are very close to multiples of the basic frequency. For the awareness of the superiority of smooth strings of even thickness, cf. Ptolemy, *Harmonics* 1.8.

consonances,[6] and the common musical settings that include strings and double pipes outside the Greek area seem to imply that at least certain Near Eastern pipes shared in the pitch systems that determined the tuning of the lyres.

The production of such instruments probably involved copying models that had worked out well, or also the application of rules of thumb in the first place, perhaps followed by reworking the details of individual holes afterwards.[7] In any case, the preconditions for the evolution of a resonance-guided tuning are much worse even in wind instruments of this kind than in stringed instruments: whereas a new set of finger holes always requires building an entire new instrument, experiments with lyre strings are quick and easy. All in all, it is therefore highly probable that resonance-based tonalities first evolved on lyres and harps and were transferred to pipes and flutes only subsequently (and often only partially).

The employment of certain strings, notes or fingerings in certain contexts, the establishment of resonance, and the construction of instruments necessarily lead to the formation of related concepts in the brains of those engaged in such actions. Whenever these skills are shared, whether in performing together or, especially, in passing them on in a master-pupil relation, those concepts are likely to be expressed through language: hence, specific terms are coined for distinct ideas. We shall see below, how different these may be from culture to culture, even if related to superficially similar underlying structures. When musical terminology is finally set down in writing, we must anticipate to find primarily such practice-related terminology. Only after considerable time of theoretical scrutiny, can we expect musical discourse to develop more abstract schemes, designed to grasp facts only implicit in the practitioner's art; and, even then, it may take centuries before the language of theory is fully emancipated from its immediately practical origins – if it ever is.

Once emerging music theory is pursued for its own sake, it may be felt that certain questions, especially regarding quantification, cannot be answered on the basis of existing instruments. Consequently, experimental instruments are constructed for specific purposes, most often for measuring pitch relations. The best-known is the canon (in its simplest form: monochord), which Greek theorists employed from the 4th century BC on, and which was perfected by Ptolemy in the 2nd century AD.[8] The study of intervals by means of the monochord (or, in fact, the physical properties of any instrument) leads to their numerical description as ratios. This approach coexisted with another description, which was doubtless closer to the language of practicing musicians: concatenating intervals *perceived* as similar, leading to expressions like 'ditone' and 'tritone' (which yield to a calculation in terms of ratios just as well), but also 'semitone' or 'third of a tone' (which cannot be expressed as ratios and thus led to a conflict of theories).

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[6] Cf. e.g. Barker, A, "Heterophonia and poikilia: Accompaniments to Greek melody", in Gentili, B. / Perusino, F., (eds.), *Mousike. Metrica ritmica e musica greca*, (Pisa/Roma 1995), pp. 41–60; Hagel, S., "Calculating auloi – the Louvre aulos scale", in Hickmann, E. / Eichmann, R., (eds.), *Studien zur Musikarchäologie* 4 = *Orient-Archäologie* 15 (2004), pp. 373–390.

[7] On possible traces of fine-tuning finger holes cf. Landels, J.G., "Fragments of auloi found in the Athenian agora", *Hesperia*, 33 (1964), pp. 392–400; pl. 70: p. 395

[8] Cf. Creese, D., *The monochord in Ancient Greek harmonic science*, (Cambridge 2010).

It is important for our topic that the two types of description presuppose a different instrumental background. The perception-based approach goes well with any type of instrument, but particularly well with those kinds in which the physical parameter(s) that define the pitch cannot be ascertained by eye. The most typical example is the lyre, where all strings are roughly of equal length, their pitch depending on thickness and tension, the latter measurable only by means of sophisticated devices. Following the model of the lyre, experimental instruments may be conceived which merely provide a large set of tuneable strings.[9] In contrast, ratio-based theory can only emerge on the basis of instruments in whose construction the ratios are visible, at least in good approximation. Here the classic example is the fretted lute – but surprisingly, the ancient evidence never associates ratio theory with this instrument type. In Greece, it seems to have been absent or at least thoroughly marginalised in the era when ratio theory emerged (i.e. before the late 4th century). Thus the original model for the novel way of describing intervals was probably provided by the placement of finger holes in wind instruments, perhaps adopted from their makers' guidelines.[10] Obviously this, in turn, demands resonance-oriented wind instruments.

Pitch systems

All the 'tunings' and 'scales' we are dealing with here are heptatonic. Even if they are not strictly heptatonic – we will discuss such examples later in Greek context – they cannot be understood but against a heptatonic context.[11] With such a universal assertion, and in the face of the fact that serious misunderstandings about the matter have turned up in relation to the Near Eastern sources, we must be careful to make entirely clear what 'heptatonic' means. In principle the initial definition of Wikipedia says it all: "A heptatonic scale is a musical scale with seven pitches per octave"[12] – though we might favour the less ambiguous wording "where the octave is divided in seven steps". Anyway, everything depends on the octave, and on the idea that pitches exceeding the octave somehow merely 'repeat' those within it, in contrast to musical systems that do not attribute a special status to the octave, or in where the extension of a scale beyond its range produces notes that do not stand an octave apart from an already established note. In such systems, the notion of '-tonism' has little or no value. On the other hand, there are musical systems, in which the octave is crucial, but divided into another number of steps – for instance, five in 'pentatonic' music.

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[9] Cf. speculations on the nature of the '*epigoneîon*' and the musical theorists mentioned in Plato's *Republic* (531a) and the Pap. Hibeh 13: West, M.L., "Analecta Musica", *Zeitschrift für Papyrologie und Epigraphik* 92-1992, pp. 1–54: p. 21; West, M., *Ancient Greek music*, (Oxford 1992), pp. 78–79.

[10] In principle, approximate ratios can also be retrieved from the lengths of the various air columns in a pan-pipe. Here, however, the tuning was apparently done by ear (partly filling tubes of similar length with wax), which would not readily occasion an interest in resulting air column lengths, while the placement of a finger hole is generally prone to being measured out beforehand.

[11] Cf. Franklin, J.C., "Diatonic music in Greece: a reassessment of its antiquity", *Mnemosyne*, 55 (2002), pp. 669–702.

[12] http://en.wikipedia.org/wiki/Heptatonic_scale, retrieved on 24 Aug. 2010. Unfortunately, misconceptions and erroneous mixture of conceptions start with the second sentence of the article.

All this is straightforward enough. The only complication is represented by sets of pitches that form a scale which falls short of an octave. Here, too, the term 'heptatonism' can be meaningful, if two conditions are met: (1) the musical culture in question otherwise does emphasise octave relations, and (2) the pitches are arranged according to an obvious rationale that, if extended, yields seven steps per octave.

Within the large domain of heptatonism, three variants concern us here. The first is the so-called 'Pythagorean tuning', which owes its misleading name to its prominence within Pythagoreanising Platonism, depending mainly on Plato's *Timaeus*. It is created by tuning, for instance a row of strings, by alternating pure fifths and fourths up to the point where there is no gap larger than a tone (i.e. the difference between a fifth and a fourth). The resulting scale consists of whole tones (ideally 204 cents) and 'leimmas', small semitones (90 cents), the latter being separated by two or three tones. For convenience, the distribution of tones and semitones in a particular chunk of a Pythagorean heptatonic scale can be designated by modern note names without accidentals, as long as it is made clear that no specific pitch is intended ('relative pitch notation'). One must however bear in mind that modern instruments do not play in Pythagorean tuning, so that a reproduction on, say, a piano, will give a misleading impression as regards the fine nuances of tuning. In fact, a stringed instrument tuned in fifths and fourths throughout exhibits a relatively high degree of internal sympathetic resonance, but it is ill suited for playing thirds or sixths: all of these are 'out of tune', i.e. they deviate considerably from their non-'Pythagorean' resonant variants.

This problem takes us to the second class of possible heptatonic scales: modified diatonic tunings. Here the notes of a quasi-'Pythagorean' pattern of tones and semitones are slightly adjusted, usually to achieve resonant thirds and sixths, or a compromise between resonant fifths and fourths at the one hand, and resonant thirds and sixths on the other. Much of Western music history from the Renaissance on was concerned with finding an optimal solution to this problem in the context of Western chordal harmony.

Thirdly, there are scales which I will term 'equidistant heptatonic'. These may be heptatonic only in the extended sense: their fourths comprise three steps and/or their fifths four steps, which links them to the realm of heptatonism as opposed to pentatonism etc. Their smallest intervals, however, do not exhibit the familiar opposition between tones and semitones. Instead they are rather homogenous. The reason for this is that their sizes are not determined primarily by aesthetic principles, but by manufacture: the physical space that determines them was measured out in equal distances, which results in near-equal intervals. This is true for the finger holes of many wind instruments in the archaeological and ethno-musicological record, and it may also be true for lute frets. Notably, some ancient Egyptian double reed pipes employ this principle.

The dichord system of the cuneiform sources

Having mapped out those parts of the conceptual and tonal landscape that may concern our topic, I will now attempt to locate within it what we know of ancient Near Eastern and Greek music.[13]

Cuneiform sources give us mainly a basic vocabulary, which was surprisingly consistent from the earlier evidence of the second millennium up well into the first. Its core is represented by a set of fourteen expressions. All of these can denote 'dichords', but half of them also has other, although interrelated, meanings in different contexts. What is a 'dichord'? Western music knows no such concept. Related is the idea of an interval: a combination of two sounds (whether conceived as simultaneous or in succession). A dichord is no interval, however, since its constituent notes are not defined in relative pitch: each of them may assume one of two states a semitone apart (though not in different direction), so that the interval in between may change between a fifth and a tritone, or a fourth and a tritone, or between a major and minor third, or a minor and major sixth.[14] For a systematic description of a tonal space, such a terminology is evidently completely impractical. But as soon as one understands it as referring to the strings of a model instrument, the confusion clears up, and one is pleasantly surprised with an amazingly concise practice-oriented system: a dichord – hence the name by which we call it – is primarily a pair of strings (Greek *khordai*). When tuning the instrument in different ways, almost every string may be altered, and with it the sound and function of the intervals. For the player, however, it is still the same pair of strings, easily identifiable between performers by its dichord name: it would have made no sense at all to devise different names according to the actual nature of the interval, let alone to resort to the slippery terrain of melodic/harmonic function.

But this is only one side of the dichord approach. The reader may have noticed that in order to cover all the fifths, fourths, thirds and sixths even in one octave, fourteen terms would not suffice. But this is not what the system aims at. Where its classical codification defines a fourth, it does not give the corresponding fifth that would complete the octave.[15] Where it defines a fifth, the corresponding fourth is missing. And a similar complementarity exists between thirds and sixth. In other words, the system incorporates a very strong element of octave exchangeability.[16] In this respect, the notion of dichord appears more akin to the modern notion of a chord, where the designation of an '*a* minor' chord, for instance, tells us nothing

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[13] For discussion of some particular points and a bibliography to this section, cf. Hagel, S., "Is *nīd qabli* Dorian? Tuning and modality in Greek and Hurrian music", *Baghdader Mitteilungen* 36 (2005), pp. 287–348.

[14] Colburn, J., "A new interpretation of the Nippur music-instruction fragmens", *Journal of Cuneiform Studies* 61 (2009), pp. 97–109, provides thought-provoking arguments for additional terms for seconds. I am not convinced, though, partly because their derivation seems too artificial to have arisen in musical practice, partly because it requires an application of octave invariance that is ultimately self-contradictory (in dichord names that are quoted as fifths, one must apply octave doubling to pin down the corresponding fourth – just because the supposed derivation does not work with octave-invariant dichords).

[15] For the moment, assuming, that they *are* a fourth and a fifth in a given tuning, as is usually the case. Each of the pairs gives a fourth and a fifth in six out of seven tunings, and two tritones in the seventh.

[16] In the 'Retuning Text' UET VII 74, the notion of the octave surfaces more directly, when notes one octave apart are always retuned together.

about the number and actual distribution of *a*'s, *c*'s and *e*'s. Here, by the way, our modern musical terminology nicely shows how little systematic coverage of possible conceptions we may expect from any historical system: in the case of chords we use primarily abstract notions ('major chords', 'minor chords' etc.), which are readily qualified in relation to the system of scales ('*G* major chord'), but cumbersome to pin down in ultimately practical terms ('*G* major chord in second inversion, with an additional root note an octave below'). In contrast, our intervals are pitch distances, not primarily thought about in terms of harmonic usage, and hence not subject to the process of inversion. Ancient cuneiform dichords share characteristics of both: they are, so to speak, two-note chords, which gives the designation 'dichord' a fine second level of meaning.

Thus the concept of dichords is evidently independent of the arrangement of notes within the octave (or, actually, also beyond the octave, since the model instrument has nine strings), but classifies all the sufficiently concordant intervals as belonging either to the fifth/fourth type or the third/sixth type. This is clearly an element of abstraction. But this abstraction is not of a kind that would go beyond the purely practical domain. The employment of dichord names (in combination mainly with numbers) for a kind of musical notation in Ugarit shows that practical music was in some way perceived as based on dichords. Their employment in this context can hardly be interpreted otherwise than in terms of a basic 'intervallic harmony', which guided the performers of the accompaniment, while the melody of the song was known and thus needed not be notated.[17] The concept is not entirely unlike a modern notation of guitar chords, apart from the fact that the latter are usually placed above the lines of text, while the Ugaritic notation, in a less helpful way, is written in a separate block beneath it.[18]

Given the recognition of the octave as establishing quasi-identical notes, the usage of 'abstract' dichords enables performers to identify the appropriate 'harmony' on their instruments, regardless of individual ranges: this is especially vital for orchestras where diverse instruments like harps, lyres and pipes play together, which may produce matching notes in octave relations but not easily similar pairs of notes. Here every musician would internalise the dichords as applicable to their specific instruments. In some cases, like harps and lyres, this would be straightforward, linked to the individual strings just as on the model instrument, albeit starting and stopping on different pitches, according to the specific string lengths. Pipes would presumably play in one 'tuning' only – but it would have been possible to provide sets of pipes in different tunings, playing dichords of the same name with identical fingering. This, it must be noted, is presently pure speculation.

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[17] Of course I do not want to imply the existence of a fixed melody; if carried out by a solo singer, it may in fact have been largely improvised, while still following traditional patterns.

[18] For the persistent pattern 'dichord – number – dichord – number…' of the Hurrian hymns, cf., as a random example from the internet, the following notation of a guitar accompaniment to a modern hymn, a sequence 'chord – number – chord – number', also given separately from the text: "D x2 G x1 D x3 A7 x2 D x2 G x1 D x2 A7 x1 D x1" ('Amazing Grace', retrieved from http://www.chordie.com/chord.pere/www.guitaretab.com/d/daniel-thomas/124540.html on 24 Aug. 2010). Similar notation for instrumental preludes, interludes and postludes only, e.g. at http://www.cowboylyrics.com/tabs/green-pat/rain-in-lafayette-9249.html, retrieved on 24 Aug. 2010: "D (2) G (1) D (3) G (1) D (4) A (3) D (6) A (3) D (6) G (1)" etc.

Lutes may have been tuned by shifting their frets, again resulting in identical finger positions for the same dichords across the various tunings. All this would demand little 'theoretical' effort. Likely, the development of what appears to have been a unified system was based on the recognition of one 'master instrument' at a certain point in history; but the meaning of most of the dichord names is so obscure that a complex evolution involving several instrument types synchronously or in succession cannot be ruled out: the nine-string model might also be a projection of a pre-existing practice onto a particular instrument.

Finally, dichords are linked to tunings. There are seven possible fifth/fourth relations within the seven notes of an octave, and there are also seven possible diatonic tunings of its range ('octave species'). The cuneiform system ingeniously associates the two, by the fact that each fifth/fourth dichord may be thought of 'generating' one tuning. This is done by attributing a sense of direction to the intervals, defining fifths as falling and fourths as rising within the tuning process. So when tuning a lyre or harp, one starts from a particular string and proceeds in alternating falling fifths and rising fourths. The resulting tuning is called by the same name as the first dichord that was tuned, i.e. the one starting from the initial string. Again, this is eminently practical: if the performer must tune his instrument to, say, *išartu*, she or he need not have memorised anything like a pattern of tones or semitones, but merely know the dichord of the same name – a piece of knowledge, as we have seen, that lay at the core of their art anyway (cf. Figure 1).

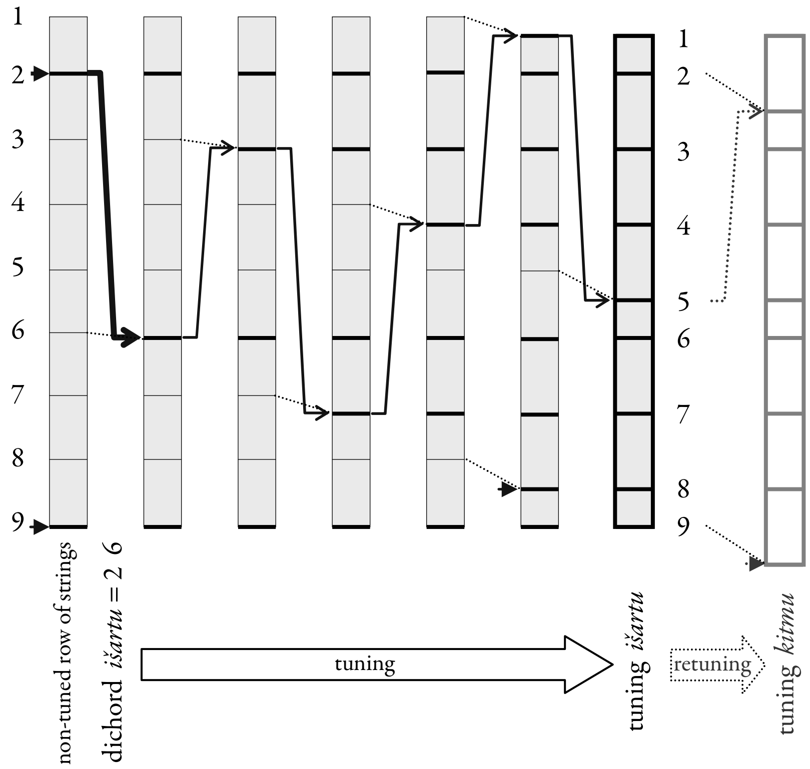

Figure 1: tuning the *išartu* scale from the dichord *išartu*

Often, however, the instrument would already be tuned to a particular scale, while the instrumentalist needed quickly to change to another one. Here again, one might follow the same principle: start from the eponymous dichord and check the sequence of fifths and fourths. At one place you will encounter a tritone instead of

a pure interval. Correct this, and the following ones, until you have completed seven steps and would return to the initial string: there you are. At first glance this procedure appears straightforward and efficient – but it has a severe drawback. If you apply it throughout, you always establish the required intervals by tuning downwards, decreasing the pitch and the string tension. After merely tuning forth and back between two scales once, the instrument is pitched a semitone lower than it was before. Consequently the sound quality is noticeably diminished. A very few more retuning processes, and the lowest strings cease to sound altogether, not to mention the fact that the vocalists voice but serious complaints. In practice, it is therefore inevitable to ensure the maintenance of an overall 'standard' pitch throughout the processes of retuning. This cannot be done in a reasonable way except by confining the retuning process within strict boundaries. How can this be achieved? Possibly by the precept not to tune beyond a given scale in one direction, and if it is not possible to reach the target scale in this way, to proceed in the opposite direction instead, tuning by *rising* fifths and *falling* fourths instead. Such a precept seems fine enough when we analyse the tunings by means of modern diagrams. In practice, it involves keeping track of the tuning reached at whatever stage. Now this is certainly not a problem for any musician who knows his or her sequence of seven tunings/dichords just as we are familiar with the circle of fifths. All the same, the ancients seem to have adopted a still much simpler rule, which implicitly entails exactly such a restriction as required: the central string is never retuned.[19] On the nine-stringed model instrument, this limits the sequence, as shown in Figure 2, between *qablītu* and *išartu*. Thus the most straightforward way to establish a new tuning out of any other – and even without knowing the present one – was to start from the eponymous dichord and proceed in falling fifths and rising fourths, as described above, until arriving at the central string. If all the intervals encountered so far were pure and needed no retuning, one would go back to the initial string and repeat the process, but in rising fifths and falling fourths, again until the central string is reached.

[19] The limits of the retuning process are inferred from the fact that in UET VII 74 the process stops at *išartu* in one direction, to be reversed afterwards. The starting and end points are broken off, but it seems beyond doubt that all seven tunings were covered and more than likely that no semitone-shifted *išartu* would have appeared at the other end (in practice, one would need each tuning clearly defined, if only for the sake of unequivocal communication between instrumentalists). Since *išartu* and *qablītu* are not singled out but for their association with a central-string-based tuning (*qablītu* starting from this string, both being the last tuneable without changing it in either direction), it is very probable that their marginal position is determined by the central-string rule. Conversely, it would be an odd incidence to find the central-string rule as the side effect of some unknown reason to have *qablītu* and *išartu* as the limits, of all the equally possible seven choices – note especially that the starting position is not determined by the first or last string, or by the dichord appearing first in the list of CBS 10996.i.

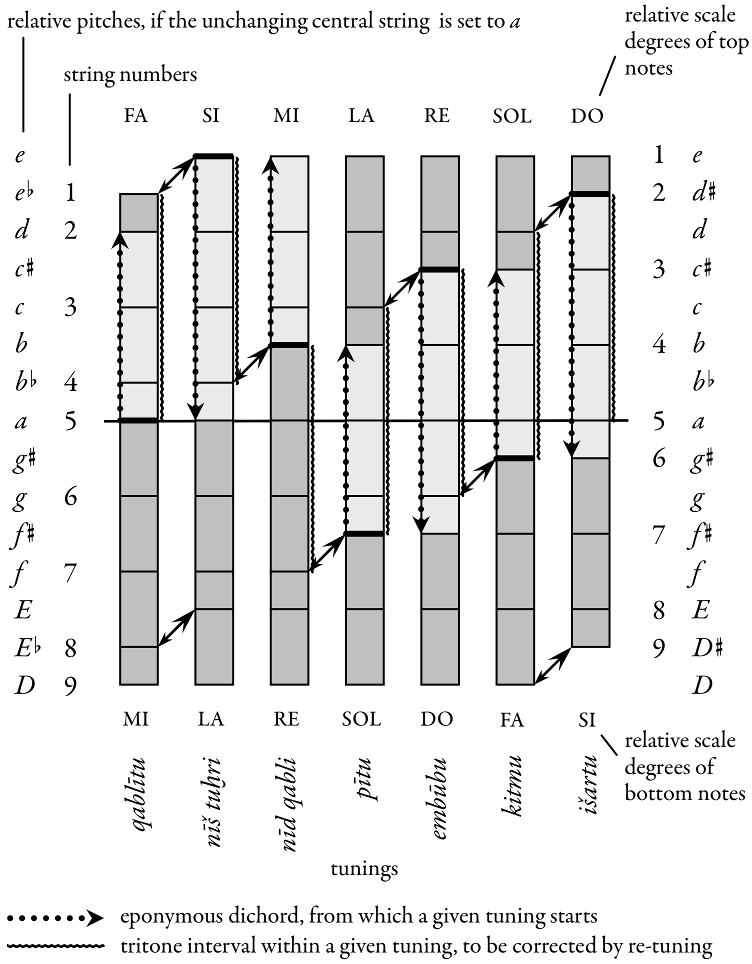

Figure 2: The ancient Near-Eastern (re)tuning cycle[20]

On the nine-stringed model instrument, therefore, called ${}^{\text{ğiš}}$zà.mí in UET VII, the retuning sequence appears defined by the notion of a central string – whose centrality of course depends on the number nine.[21] The same nine strings are attested in *Nabnītu* 32 i, where their names are given: here the fact that they are numbered inwards from both directions demonstrates that the notion of the fifth string as a centre was deeply ingrained in the system. It seems that a nine-stringed instrument played a crucial role in musical practice (at least music-educational practice) long enough that not only its string names would become the basis of a canonical description, but also the particular retuning boundary between *išartu* and *qablītu* that depends on its nine strings.[22] The name of the dichord and tuning *qablītu*, "middle", which start from the fifth string, evinces that the nine-string standard is

[20] For perfect symmetry within the transcription to modern notes, one would identify the central string with *d*, thus making *pītu* the natural scale and attributing three flats to *qablītu* and three sharps to *išartu*. I have used *a* instead, which makes the diagram directly comparable to those of ancient Greek music, where the 'middle' string, *mésē*, a fifth below the highest, is best equated with modern *a*. If zà.mí string lengths roughly corresponded to those of typical Greek citharas, this would also result in approximately correct pitch.

[21] If a similar sequence were to be built not on nine strings, but merely on the seven that are necessary to establish the heptatonic scales without octave doublets, dropping the two lowest strings, the fourth string would be central. If it is kept constant, the sequence would start at *nīd qabli* and end with *nīš tuḫri*.

[22] For possible evidence for nine strings in the Hurrian hymns cf. Hagel, "Is *nīd qabli* Dorian", p. 320. In the (roughly) Neo-Babylonian text YBC 11381, the nine strings still appear in what seems to be a very performance-oriented context, labelling nine benedictions in turn (cf. Payne, E.E., "A new addition to the musical corpus", in: S.C. Melville/A.L. Slotsky (eds.), Opening the tablet box. Leiden/Boston (2010), pp. 291–300).

older than the dichord/tuning terminology as we know it. In its canonical formulation, ancient Near Eastern music is structurally heptatonic, but enneachordal.

In any case, there are two directions of retuning, up from *qablītu* to *išartu* and down the other way. The upwards variant has the great advantage that here dichords and tunings are directly associated, because the establishment of a resonant dichord out of a tritone brings about the tuning of the same name. In *qablītu* tuning, for instance, the tritone resides between string 1 and 5, giving an 'unclear' *nīš tuḫri*. A resonant *nīš tuḫri* is achieved by tightening string 1 to a pitch a semitone higher, and as a consequence, the instrument is in *nīš tuḫri* tuning. Accordingly, the instrument is first tuned upwards in UET VII. When tuning downwards, the relation between concords established and resulting tunings is however cumbersome. Starting from *išartu*, for instance, one 'corrects' the dichord *qablītu* by slackening string 2 (and 8 an octave below), resulting in *kitmu* tuning. This is little helpful; the instrumentalist would either have to learn these sequences, as laid out in UET VII, by heart, or his or her mind would have to jump back and forth between three adjacent terms in the series. Here it is in fact easier not to think in terms of concords *established*, but of concords *destroyed*, which demands no more than the command of the ordered series of seven terms as such: if you have an *išartu* tuning, destroy the *išartu* consonance, and you will get *kitmu*, the next in the series. Such a precept may well lie behind the lower part of the list in *Nabnītu* with its puzzling *siḫip* lines.[23]

The cuneiform system is described in terms of a row of strings arranged according to pitch. This is by no means a matter of course – often strings are ordered according to a different principle, as for instance on the Ethiopian *begena* lyre; these are usually called 're-entrant' tunings.[24] It seems, the constitution of an order according to pitch must have been grounded in a conscious effort to do exactly this. In the case of Near Eastern music, it presupposes the establishment of a heptatonic standard, perhaps itself originating in 're-entrant' tunings in fifths and fourths, if the process took place on lyre-like instruments. Harps, on the other hand, provide a strong impetus for ordered tunings, because their strings are ordered according to length, which naturally translates to pitch. Pipes of all kind also imply ordered pitches, but do not easily give rise to heptatonism by themselves. The notes within an octave can be ordered only as the performer knows which notes should be placed in that specific octave (because it is hardly possible to insert additional strings between those already tuned on an actual instrument). In this way it is finally established that a fifth is tuned leaving out three strings, and two in the case of a fourth. All in all, it seems that some awareness of the importance of the number

[23] Cf. Arndt-Jaemart, J., "Zur Konstruktion und Stimmung von Saiteninstrumenten nach den mesopotamischen Keilschrifttexten", *Orientalia* 61.4 (1992), pp. 425–447: p. 435. Lines 12–16 would then mean: "*išartu* – enfeebling *išartu* – *kitmu* – enfeebling *kitmu* – *enbubu*…"; on this interpretation, the much discussed question whether the *si□ ip*-qualified terms refer to tunings or dichords actually loses its point: both are destroyed at once, the manipulation of the tuning being carried out on its eponymous dichord.

[24] The term is less than felicitous because it implies a non-reentrant standard, within which 'starting points' of new ordered series are felt.

seven would already have been part of such a heptatonic music culture in a very early stage.

The names attached to the dichords and scales have puzzled scholars, and many of them so far escaped convincing explanation.[25] This is only to be expected. Their meaning must not be sought in terms of the ready-made system, let alone in its abstract graphical representations as stars or whatever, not even if these are found in the ancient record.[26] Did they originate as dichords or as tunings? The terms for the thirds/sixths class of course only exist as dichords, but this does not decide the case, since they may be later extensions: after all, two of them are seemingly derived from ones of the fifths/fourths type, albeit in an apparently unsystematic manner: *titur qablītu* and *titur išartu*. The conceptional path from dichord to the tuning it generates is doubtless smoother than vice versa. On the other hand, the term *embūbu*, "double pipe", might make more sense as a scale.[27] The actual development probably followed much more convoluted trails than most of us would like to imagine.

Anyway, we must never forget how little we know about the music whose basics were communicated by the excavated system of terms. We know nothing about the absolute pitch, until the zà.mí is identified and its (approximate) string lengths are known.[28] We do not know how the system was applied to other instrument classes, particularly instruments with more than nine strings. We must not forget that the dichord system perhaps applied to only a very small segment of ancient Near Eastern music-making. Finally, we must remember that tunings are not modes. Any of the seven tunings may have been associated with a particular mode defined by typical starting, focal and final notes, prominent dichordal 'harmonies' and their interplay.[29] Or there may have been more than one way of putting each tuning to modal use.[30]

Octave-enhanced resonance

The enneachordal nature of the system, which seemed to go beyond the ephemera of an eventual codification, allows us at least to speculate about some essential

[25] Cf. Krispijn, Th.J.H., "Musik in Keilschrift. Beiträge zur altorientalischen Musikforschung 2", in Hickmann, E. et al., (eds.), *Studien zur Musikarchäologie* 3 = *Orient-Archäologie* 10, pp. 465–479: 471.

[26] For modern stars, cf. Vitale, R., "La musique suméro-accadienne. Gamme et notation musicale", *Ugarit Forschungen* 14 (1982), pp. 241–263; for an ancient 'musical star' cf. n. 32 below.

[27] The alternative that the two boundary notes of the *embūbu* interval somehow refer to two prominent notes on the pipes of a pair is hardly viable: *embūbu* covers a fifth, but no known ancient pair of pipes has so large an interval either between the highest or between the lowest notes of each pipe. Octave-invariance, it is true, would turn *embūbu* to a fourth, such as is well attested for Greek auloi; but this would entail that the pipes exceeded the range of the nine strings by just a semitone at the lower end or a tone at the higher end. So it would become very difficult to understand from a musical viewpoint why the instruments' ranges would not have been aligned outright, so that, for instance, the highest finger holes would have corresponded to strings 1 and 4.

[28] On strings and pitches cf. Hagel, S., *Ancient Greek music: A new technical history*, (Cambridge 2009), pp. 88–92.

[29] I have tried to unravel some of the modal characteristics of the Hurrian hymns in "Is *nīd qabli* Dorian", pp. 307–338.

[30] After all, the assumption of a 1:1 relation between tunings and modes might be bolstered by the fact that songs are found classified by tuning (KAR 158 VIII, see below) – but this is far from conclusive, since tunings are readily classified, while modes, which need not even exist as explicit concepts in the musicians' minds, are difficult to pin down.

ingredients of modality. Of nine notes, the two highest are duplicated at the lower octave; and we have seen that their functional equivalence was taken for granted. This means that when dichords are played on such an instrument, several of these can avail themselves not of two but of three notes by including the octave counterpart of one boundary note. In this way, some dichords can be executed with significantly higher resonance than the others. This is particularly important in the case of fifths and fourths, where, due to the simple frequency ratios involved, the resulting three-note dichords blend especially well. Four possible tri-dichords of this sort exist, involving either strings 1 and 8, coupled with either 4 or 5, or 2 and 9, together with either 5 or 6. Not all of these, however, are available in every tuning: wherever the tritone starts from string 1 or 2 downwards, the corresponding set is not among the concords (cf. Figure 3).

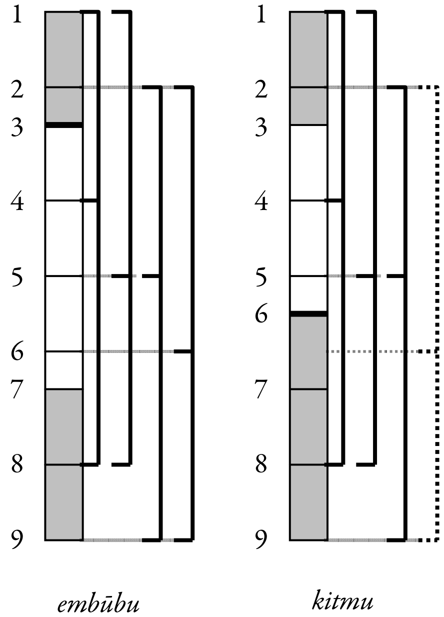

Figure 3: Examples for octave-enhanced resonance in Near-Eastern enneachords

Even so, no tuning has fewer than three octave-enhanced fifths/fourths, so that none is seriously impaired as regards its modal capabilities. So it is no wonder that we find all tunings in actual use, in the song list of KAR 158 VIII (cf. Table 1). The comparison of *kitmu* with *pītu*, the former sporting fewer octave-enhanced dichords yet covering four times as many songs, might indicate that three octaves divided by fourths/fifths were definitely felt sufficient to support a full-fledged modal scale. Admittedly, though, we do not know whether the canonical nine played a practical role at the time (ca. 12th/11th cent. BC) and the place (Aššur) where the list was compiled, so that the value of its testimony in this respect is necessarily limited.

	high fourths	high fifths	songs in KAR 158 VIII
išartu	1	2	**23**
kitmu	2	1	**17**
embūbu	2	2	**24**
pītu	2	2	**4**
nīd qabli	2	2	**?**
nīš tuḫri	1	2	**?**
qablītu	2	1	**?**

Table 1: Octave-enhanced resonance and number of songs in KAR 158 VIII

In any case, wherever the gamut of a ninth was prominent, we must assume that it imprinted its characteristics upon the mode or modes associated with each tuning. In particular, we expect that the highest and lowest two notes enjoyed a prominent status, and similarly the central note: apart from those mentioned, string 5 is the only one that can take part in two octave-enhanced sets of the fifth/fourth type. Here we have an additional musical explanation for the structural significance of this central string of nine. Strings 4 and 6, which take part in no more than one, may still have had some importance – perhaps serving as contrastive foci.

Conclusion

On balance, as far as I can see, every single feature that ancient Near Eastern musical texts exhibit is intimately associated with instrumental practice. There is no evidence for wider-reaching abstraction. Scales are conceived as tunings, and terminology as far as understood gives no hint about any fine-tuning that would deviate from the 'Pyhtagorean' scales arising from pure fifths and fourths.[31] Beyond the mere codification of practical aspects, so far we only have a Late Babylonian heptagram (CBS 1766) whose points are labelled as string names in such a way that the circumference takes us through the seven steps of the octave, while the drawing of the star reproduces the fifths and fourths (depending on whether counting clockwise or anticlockwise) of the tuning and retuning process.[32] This is doubtless an ingenious representation of musical facts in diagrammatical form, testifying to a profound understanding of the implications of the tuning process within an octave-invariant paradigm.

[31] There have been speculations about certain texts reflecting fine tuning processes (Kilmer, A. / Tinney, S., "Old Babylonian Music Instruction Texts", *Journal of Cuneiform Studies* 48 (1996), pp. 49–56; Kilmer, A.D. / Tinney, S., "Corrections to Kilmer/Tinney 'Old Babylonian Music Instruction Texts', JCS 48 (1996)", *Journal of Cuneiform Studies* 49 (1997), p. 118; Smith, J.C. / Kilmer, A.D., "Laying the Rough, Testing the Fine (Music Notation for CBS 10996)", in Hickmann, E. / Eichmann, R., (eds.), *Studien zur Musikarchäologie* 1 = *Orient Archäologie* 6 (2000), pp. 127–144; Kilmer, A. / Peterson, J, "More Old Babylonian music-instruction fragments from Nippur", *Journal of Cuneiform Studies* 61 (2009), pp. 93–96.), but these have little explanatory value (cf. Colburn, "New interpretation", pp. 97–109), and have also not established any definite musical meaning. My own speculations about a possible tuning with pure thirds in the Hurrian hymns are based on dichord statistics and do not suppose a theoretical formulation behind or beyond the practice (cf. n. 29 above).

[32] Horowitz, W., "A Late Babylonian tablet with concentric circles from the University Museum (CBS 1766)", *Journal of the Ancient Near Eastern Society* 30 (2006), pp. 37–53; Waerzeggers, C. / Siebes, R., "An alternative Interpretation of the seven-pointed star on CBS 1766 (Horowitz, JANES 30)", *N.A.B.U.* 2007 pp. 43–45.

On the other hand, we have no evidence for abstract terms for intervals classified by size, such as ‘fifth’, ‘fourth’, ‘tone’ or ‘semitone’.[33] As a consequence, we know of no explicit interval arithmetic of the sort of ‘an octave consists of a fifth plus a fourth’. No doubt the idea as such was represented in the musicians’ mind, but the seeming absence of specific terminology would have precluded theoretical formulation. Lacking interval arithmetic of the ‘straightforward’ sort, finally, there was hardly any point from which a description of pitch relations in terms of ratios would have started. Surely, the Babylonians would have had at their command the mathematical means to deal with pitch arithmetic – but so far there is no evidence that they employed them in that way. And indeed it would be very surprising if such evidence ever came to light, given the absence of prerequisite key concepts in the tablets that have so far been identified as treating musical matters.

The Greek ‘system’

In the Hellenic culture, the lyre and the double pipe (aulos) were the most prominent instruments. This already demonstrates interchange of some sort with the Near East, although the nature and age of common origins are unknown. Up to the 5th century BC, our knowledge of Greek music is mainly determined by literary references, iconography and the occasional find of pipe fragments. In the late 6th century, however, as transpires from shadowy later accounts, musicians began to reflect on their art, which led to the analysis of scales and their mutual relations. A hundred years later, books were written that used ratio arithmetic to describe basic pitch structures; and after another hundred years, a systematic comprehensive description of the tonal space of Greek music was given by Aristoxenus, which remained canonical up to the end of antiquity.

The first stages of this process are naturally rather obscure; but we can surmise a bit of information from the terminology that they created: names for notes, intervals and scales. The convention of naming notes was derived from the strings of the lyre (not much unlike the Near Eastern terms), and later expanded by analogy.[34] The usual interval names presuppose heptatonism: the fourth is called *diá tessárōn*, ‘across four’, and the fifth *diá pénte*, ‘across five’. The name for the octave is *diá pasôn*, ‘across all’, doubtless referring to a lyre tuning in which the outermost strings spanned an octave (more on that below). Our earliest source, however, a quotation from the Pythagorean Philolaus (5th cent. BC) uses different terms: *syllabá* for the fourth and *di’ oxeiân* for the fifth.[35] The former probably refers to a sense of ‘unit’ (literally ‘what is taken together’), and might reflect early scale analysis in terms of what is later known as tetrachords. The latter means ‘across the

[33] It has been conjectured that *pismu* in *Nabnītu* 32 i 11 means ‘octave’. If this is correct, nevertheless we should not take it as ‘octave’ in the primary modern sense of an interval of a particular size if that concept seems absent otherwise.

[34] Cf. e.g. West, *Ancient Greek music*, pp. 219–223.

[35] Philolaus, fr. 6a = Nicomachus, *Encheiridion* 9, p.252.17–22 Jan: “The size of *harmonía* is a fourth [*syllabá*] and a fifth [*di’ oxeiân*]. And the fifth is larger than the fourth by 9:8. For from *hypátē* to *mésē* there is a fourth, from *mésē* to *n□ tē* a fifth, from *n□ tē* to *trítē* a fourth, from *trítē* to *hypátē* a fifth.” The term *harmonía* here evidently refers to the octave, but not simply as an interval but apparently in the sense of a fixed size structured internally so as to become a harmonious whole.

high-pitched'. This must also have originated in lyre tunings, where the interval from the central note to the top note, i.e. that spanning the high-pitched half, was in fact a fifth (cf. below with Figure 4). In this original sense, the notion corresponds to a dichord. But Philolaus no longer restrains the term to a particular location, but applies it also to the lower range of the strings, in the abstract sense of 'a fifth'. Here we seem to witness the transformation of dichordal thinking to the abstraction of interval sizes. Why the interval of a tone is called by this name, *tónos* 'stretching, pitch', is not very clear, but it is probably a sign that diatonic tunings played a chief role.[36] For smaller intervals, the term *díesis*, 'letting through', was used, which is thought to derive from the practice of half-covering finger holes on wind instruments. Scales, finally, were apparently analysed in terms of their constituent intervals, or as consisting of fourths and tones.

Aristoxenus' fully-developed system is strictly heptatonic. Its coherence is guaranteed by fifths and fourths in a sophisticated way, although it was by no means restricted to a 'Pythagorean' diatonic, but included scales with interval sizes ranging from quartertones to undivided ditones. Even so, any pure instance of a scale would have seven pitches within the octave – if less, this would count as a conscious 'omission' on the part of the composer; if more, this would result from modulation, a mixture of more than one scale.

Heptatonism, it seems, was indeed the paradigm of Greek music as far as we can trace it back; even if it was probably often subjected to modifications of just the sort Aristoxenus had in mind. I will come back to this point in a moment.

The remains of archaic Greek double pipes usually sport finger holes that are most easily interpreted in terms of heptatonism. The holes are too evenly spaced to yield tones and semitones, but also definitely not equidistant. Almost all of the extant items are however made from bone, so we cannot exclude the possibility that pipes made of more perishable materials might have looked quite different. In any case, some kind of non-Pythagorean diatonic, perhaps close to modern bagpipe scales, seems to have dominated much of archaic piping. Later sources imply that such pipes would have been used for music with microtonal divisions also, probably by half-stopping certain finger holes.

Lyres

At the same period, lyres almost universally have seven strings, both in the iconography and in literary testimony. This would go well with heptatonism, and one could imagine a full (re-)tuning cycle on seven strings, very similar to the Near Eastern evidence. Yet none of the sources reflects such a state. Already in about the 3rd century BC, the question how the seven-stringed lyre had been tuned was subject to discussion and speculation[37] – but the more informed testimonies, including a single one from the 5th century, are unanimous in placing an octave between its outermost strings. The early one is the Philolaos quotation which we have already come across: he identifies the octave and the fourths and fifths that

[36] Cf. Franklin, "Diatonic music".

[37] Cf. *Aristotelian Problems* 19.7; 19.47.

structure it with reference to lyre string names, as shown in Figure 4. The fact that the so-called 'third' string is tuned to a note a fourth from the top proves that reference is here made to the typical seven-stringed lyre, still the standard instrument of education in the period in question. To our eyes, and to those of Aristoxenus, this is a 'gapped' tuning; more neutrally it can be described as heptatonic at the bottom but pentatonic at the top.

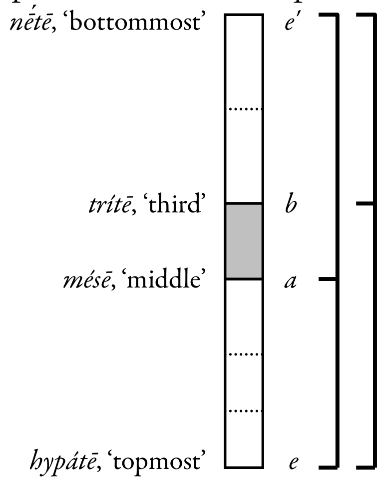

Figure 4: The seven-stringed lyre according to Philolaus

Philolaus does not refer to some specifically tuned lyre;[38] he talks about *harmonía* as such, and when he comes to prove his proposition by reference to lyre strings, there is clearly no idea that any of those mentioned might ever be tuned differently. From Philolaus' fragment we can therefore conclude, despite its brevity, that at his time the seven-stringed lyre was invariantly tuned to a 'gapped' octave, structured in fifths and fourths by two symmetric notes in the centre, and further divided by one remaining string in the upper half, and two in the lower. The particular pitches of these would define the tuning (there were of course more than one). As a matter of fact, these characteristics are corroborated by much later evidence that evidently stands in unbroken historical continuity with the lyre of Philolaus' time: the cithara tunings as described in Ptolemy's *Harmonics* still feature exactly the same structured octave (although now fully heptatonic). Surprisingly, the citharist of the 2nd century AD concert hall still refrained from following the retuning cycle to a point where the basic symmetry of the octave would be broken (cf. Figure 5; we need not discuss here the question why retuning actually stops one step short of this point in the case of upwards tuning).

[38] That he talks about a lyre at all emerges from the fact that the term *trítē*, 'third' string/note, shifted to the third step in a full heptatonic octave before it was generalised as a note name, independent of instrument.

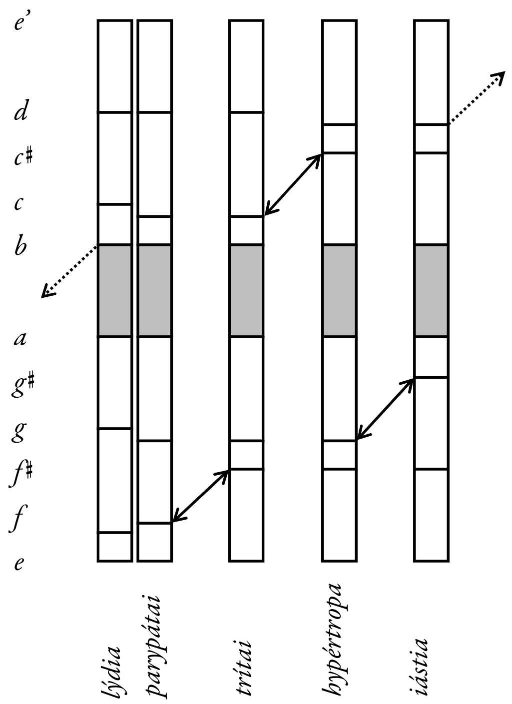

Figure 5: Diatonic cithara tunings described by Ptolemy
(Arrows indicate the basic diatonic retuning; note that there are also microtonal differences in fine tuning that may demand the adjustment of additional strings)

Whence this restriction to only a part of possible tunings? I think the answer is closely related to the 'gapping', which testifies to a preference for having an octave on the instrument to having 'all notes within it' available. Just as we have speculated for the Near Eastern tunings, here also an octave between the outermost strings meant the possibility to play octave-enhanced 'dichords'.[39] With seven strings, however, there is only one octave and therefore are only two respective dichords of the fifth/fourth kind (as compared to four on the nine-stringed zà.mí). The loss of one of these would have done substantial damage to the harmonic capabilities of the instrument, even to the resonance of its sound. Naturally it would have been regarded too high a cost for the additional modal variety gained by retuning one of the central strings. So it is perfectly understandable why one preferred to stay with a mere three retunable strings (until more strings were added).

Perhaps it was this restriction that set the Greeks on the path of pursuing microtonal variety. Unfortunately, we know little of the practical background of this part of theory: when Aristoxenus' describes various shades of tunings, it is generally hard to tell to which instrument these would apply. But at least sometimes the lyre is a very likely candidate.[40]

Tunings and modes

From about the 5th century BC on, Greek musicians developed a melodic notation, based on the principle of letters – one sign stands for one note – quite unlike anything we know from cuneiform sources. A corpus of about 60 melodies and melody fragments has survived, dating from between the 3rd century BC and the

[39] The octave resonance is explicitly named as the presumable cause for such a tuning in *Aristotelian Problems* 19.7.

[40] Cf. Aristoxenus ap. [Plutarch], *De musica* 1145d, where the observable tuning of strings seems required.

4th century AD, mostly vocal repertoire. Where sufficient portions of the melody are extant, we are able to identify modal characteristics such as focal notes or structurally important intervals. Furthermore, some of the songs can be identified as lyre-accompanied, and if so, the key in which they are notated may betray their tuning, thanks to Ptolemy's account.[41] Where we have more than one piece in the same key from the same context, it is possible to inspect the relation between modality and tuning.

Luckily, a few citharodic pieces, probably from a kind of beginner's lyre textbook, have come down to us in the manuscript tradition. The four items whose notation survives (at least to a great part) are all notated in the Lydian key and can be associated with Ptolemy's tuning *lýdia*. Nevertheless, they do not all exhibit similar modal characteristics. One short *Invocation* is clearly centred on an axis between *E* and *A*, corresponding to the old octave-enhanced 'dichord' with *mésē* on the archaic lyre, while the fourth between *G* and *D* provides a harmonic contrast.[42] In sharp opposition, a *Hymn to Nemesis* is almost exclusively focused on *G*, supported by *D*, while other notes only rarely acquire prominence.[43] Other evidence suggests that both these modal options were common.

In Greek lyre music, therefore, tuning and modality were interrelated, but not associated in a one to one relation. As so often, the reality of music defies simple categories. Whether the same would be true for Near Eastern songs, or whether there each tuning might have implied a mode, at least at some places in some periods, we will probably never know.

Auletic 'modes'

The scales of archaic aulos music are so far mostly names for us. Later sources talk about Dorian, Phrygian and Lydian pipes;[44] this may or may not result from learned reconstruction. Some kind of Dorian double-pipe layout may be reconstructed from Aristoxenus' remarks,[45] but on the other hand, the remains of instruments so far defy classification.

Towards the end of the 5th century BC, we learn, the development of Greek music took a huge leap with the invention of modulating pipes, i.e. auloi including keywork that made it possible to open different sets of holes. Such an enterprise requires the analysis of pipe scales that had previously existed side by side, and mapping them onto each other (perhaps with inevitable modifications). In fact the business of scale analysis seems to have been well underway in the first half of the century. The Roman-imperial writer Aristides Quintilianus famously mentions irregular scale forms, '*harmoníai*', which he associates with Plato's time, and

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[41] Even if a piece was written down during Ptolemy's lifetime, it is clear that we cannot assume that the microtonal details described by him would have applied to the intended performance; for the following argument, however, we need not assume more than that tunings were associated with keys, and as such constant for a given artist at a given period. This, I think, is more than reasonable.

[42] Pöhlmann, E. / West, M.L., *Documents of Ancient Greek Music*, (Oxford 2001), nr. 24.

[43] Pöhlmann/West, *Documents*, nr. 28.

[44] Cf. Pausanias 9.12.5; Athenaeus 631e.

[45] Hagel, *Ancient Greek music*, pp. 407–410.

probably thinks to be even older (cf. Figure 6).[46] These can be argued to derive from an early systematisation, at some time around 500 BC, that was related to aulos design.[47] Thus they are probably still in some way not very far removed from early classical 'modes' – though unfortunately once more reduced to scales, whose tonal hierarchies we can only guess.

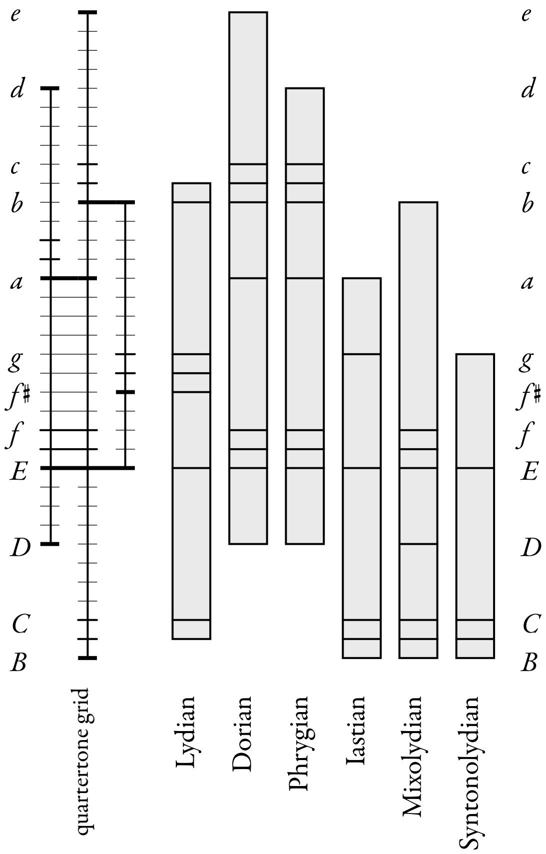

Figure 6: The old '*harmoníai*' as reported by Aristides Quintilianus
(Note that the pitch relations between the scales are probably meaningless)

In the formation of scalar theory, such an auletic approach to pitch systematisation necessarily coalesced with paradigms arising from strings; since our written sources all postdate the most important developments, it is often exceedingly difficult to obtain some glimpses of how Greek musicians before Aristoxenus would have conceived such matters. Nevertheless, I will try to give a short outline of the development, as far as I understand it currently.

A sketch of the evolution of Greek musical concepts

We start at the late archaic age, when lyres, as we have seen, in general had seven strings, which were tuned in several different ways. Quite probably the outermost strings already spanned an octave, which was internally structured by a tone that separated a lower fourth from an upper one (Figure 4 above). Likely some of the other strings also were tuned by the most resonant intervals, so that the overall character of the lyre was diatonic, though perhaps with considerable variation.

[46] Aristides Quintilianus, 1.7, p. 12–13 Winnington-Ingram.
[47] Cf. Hagel, *Ancient Greek music*, pp. 371–390.

When extra strings were added, these did not so much enlarge the ambitus, but provide additional, modulating notes. This would lead to the later canonical 'chromatic' with its sequence of two semitone steps within the fourth.

On the other hand, there was the simple aulos, playing a more pipe-like variant of diatonic, but also microtones that would later be codified as 'the enharmonic genus'. Sometimes auloi and lyres played together, ensuring a certain amount of compatibility.

At about this stage, three things of great consequence came to pass. Firstly, musicians began to give accounts for the scales they used, developing a terminology in which to speak about intervals and larger systems. Important musical vocabulary that is still in use was coined, starting from the word 'music' itself. Obviously in close connection with such endeavours, signs were conceived for a first melodic notation, at first mostly related to the aulos, but soon embracing lyre music, too. Thirdly, it was discovered that concordant intervals relate to quantitative physical differences that are describable in ratios between small integers. The clue might have been taken from the art of positioning finger holes on pipes or flutes; it seems to have been corroborated by experiments of different kinds as well – though apparently not yet on a monochord, or with strings at all.[48] The discovery had the greatest influence on Pythagorean philosophy, consequently attaching itself to the founder of the movement. It spawned a separate, mostly speculative, branch of music theory, which readily emancipated itself from the banalities of actual music-making to contemplate hypothetical cosmic harmonies.

With the invention of two kinds of mechanism, auloi grew larger and more versatile. The first development was reflected in the conception of a model scale with the ambitus of two octaves, the 'Perfect System'. It is conceived as a framework of fourths and fifths, whose inner notes can be tuned in various ways: 'fixed' and 'moving' notes – a concept that we have seen preformed in the lyre with its comparable framework '*harmonía*' with tuneable strings in between. Just as Philolaus had accounted for the lyre harmonic framework in mathematical terms, we find traces of a similar endeavour for the two-octave framework, perhaps connected to the famous Pythagorean Archytas.[49]

On the other hand, the modulating capabilities of the new generations of auloi had required that the old scales be related to each other and, if possible, aligned at their highest pitches. We can imagine star musicians and instrument makers brooding over newly-devised diagrams. Later sources give echoes from what seem to have been two different solutions to the problem. At any rate, when the 5th century BC drew towards its end, auletes who had the financial resources to commission such an instrument, were able to switch between different 'keys' during performance. Consequently, notation had to be adapted in order to write down such 'New Music', here also introducing the concept of 'keys'. Their theoretical formulation comes under the heading of '*tónoi*' or '*trópoi*'. At this stage, it seems already to have been commonplace to describe scales in terms of tetrachords, four-note units spanning a

[48] Cf. Hagel, "Calculating auloi", pp. 384–385; Hagel, *Ancient Greek music*, pp. 176–177; 333 n.21; Creese, *Monochord*.

[49] Hagel, S., "Twenty-four in auloi: Aristotle, *Met.* 1093b, the harmony of the spheres, and the formation of the Perfect System", in Hagel, S. / Harrauer, Ch., (eds.), *Ancient Greek Music in Performance*, (Vienna 2005), pp. 51–91.

fourth, that were concatenated in various ways, either directly or with a separating interval of a tone in between – though it was not before Aristoxenus that exact rules were pinned down, which kinds of tetrachord can be freely arranged in this way. A particular 'school' of musical thinkers, associated with the name of Eratocles, specially emphasised the octave, demonstrating how its different 'species' are generated by subsequently transferring intervals from one end to the other. They christened those species by the names of identical or similar modal scales. The idea was apparently of little practical importance by then; thanks to its neat layout, however, it was later to become one of the central concepts of Western music theory.

In the middle of the 4th century, the musicians' view was apparently ruled by the idea of a quartertone grid into which any scale and key could be fitted; Aristotle would simply quote the quartertone as the unit of measure in music.[50] Plato, on the other hand, adopted the mathematical description of a tuning in pure fifths and fourths for the structure of the world soul in his *Timaeus*, thus setting a standard for later 'Pythagorean' (i.e. in fact Platonising) thinkers until late antiquity. From this point on, the quest for a mathematical description of harmony in terms of ratios would remain divided into a largely fossilising branch of Platonisers and a handful of original thinkers who, sometimes more playfully, sometimes with more philosophical seriousness, searched for an optimal description of musical structures in terms of numbers.

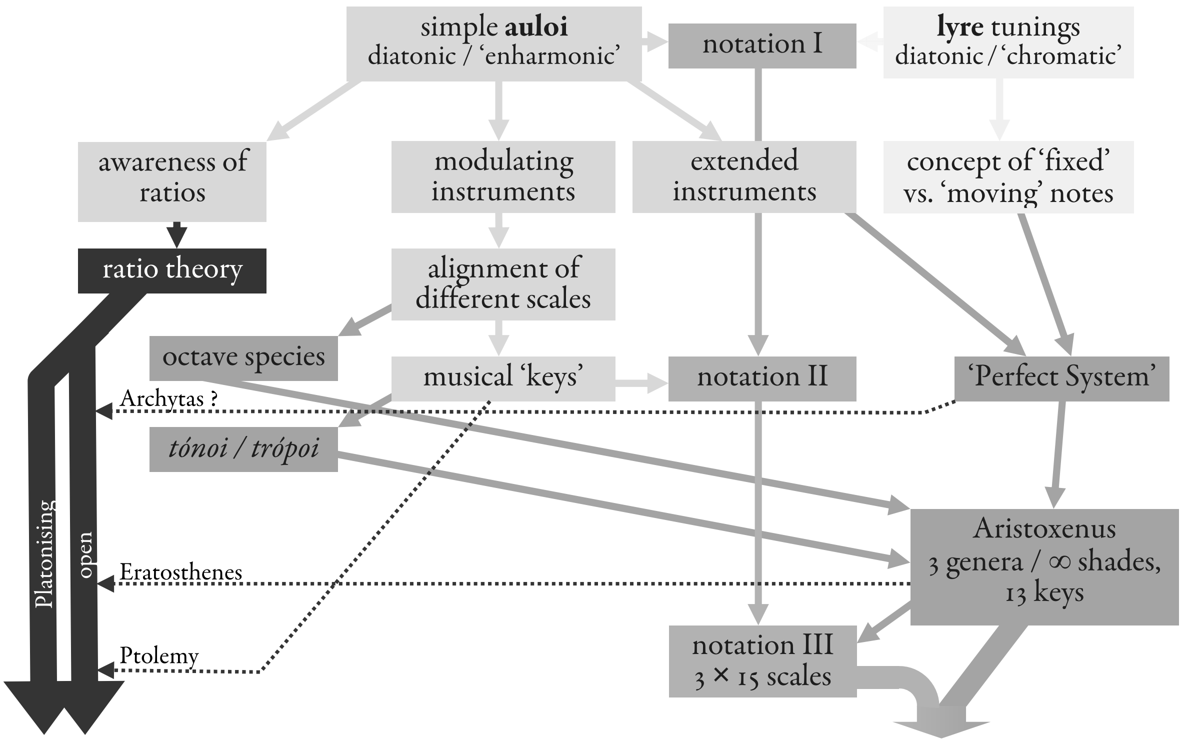

Figure 7: A model of the evolution of pitch concepts in ancient Greece

Towards the end of the century, Aristoxenus drew all strands of non-Pythagorean, practice-oriented theory together and devised his inclusive system: 'diatonic', 'chromatic' and 'enharmonic' as three genera on an equal par, in practice realisable

[50] Aristotle, *An. post.* 84b; *Met.* 1016b; 1053ab; 1087b.

in an in principle infinite number of shades, modulating through the circle of fifths (thought of as 'equally tempered') in thirteen keys, incorporating the 'Perfect System' no less than the idea of octave species (and the species of fourths and fifths). Governing principle is 'the law of fourths and fifths', according to which in every regular scale each note must either have a counterpart three notes apart that stands at a fourth from it, or one four notes apart at a fifth. Here heptatonism is finally abstracted from its origin in diatonic music and projected onto enharmonic and chromatic scales as a universal principle.[51]

In the wake of Aristoxenus' comprehensive modulating scheme, the keys of notation were subsequently expanded to fifteen – exceeding those necessary for all types of modulation, but practical for grouping in five triads. Here at last we witness the influence of theory back on practice; in Roman times, eventually, the keys introduced by Aristoxenus even came to dominate, while old ones seem to have practically died out.

Finally, Aristoxenian systematic also shaped the way in which writers of a Pythagorean hue conceived their task. Probably still in his lifetime, a work called the *Division of the Canon* tried to base musical lore upon firm physical considerations, proceeding in propositions and proofs in the manner of a mathematical treatise. It culminates in laying out the mathematical construction of the two-octave framework by construing the proper locations for bridges along a single string; the scale is conceived as enharmonic.[52] Here we do not yet encounter anything specifically Aristoxenian. Eratosthenes, however, in the next century perceived the need to devise a scheme of ratios into which all the Aristoxenian 'genera' would fit. Ptolemy, finally, embarked on working out a complete set of seven keys in all genera and several shades, all based on purely mathematical considerations, as far as possible. His ingenious work, which includes proposed tests on novel experimental instruments, finally brings 'Pythagorean' musical mathematics back to describing musical practice – albeit only lyre practice, which was confined within the seven keys his theory would admit instead of Aristoxenus' thirteen.

This very brief sketch concentrated on issues to do with pitch systems. It is important to bear in mind that the development of these went hand in hand with wide-ranging discussions of underlying and related concepts – from the nature of sound on the one hand to possible moral and consequently political influence of musical styles on the other.

Comparison

If we compare the musical cultures of the ancient Near East and the Hellenic and Hellenistic world, they have doubtless much in common: dominant instrument types as well as a heptatonic basis (both going back to times unfathomed). Greece always documented a historical connection to Anatolia by calling musical styles of central importance by the names of Lydia and Phrygia. Western Anatolia, however,

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[51] Actually, non-diatonic heptatonism was probably the invention of the 'Eratocleans'.

[52] On the *Division of the Canon*, cf. Barker, *Science of Harmonics*, pp. 364–410. The diatonic final chapter is probably a later addition, cf. Hagel, S., review of Barker, *Science of Harmonics*, *Classical Philology* 104 (2009), pp. 243–248.

is not Mesopotamia, but was culturally much more closely linked to Greece. In any case, both in Greek and cuneiform sources, heptatonism is combined with strong focus on fifths and fourths as scale-generating intervals, and an awareness of the octave as generating some sort of functional identity (and, it seems, modally important enhanced resonance on the lyre).

When we come to the written sources, however, the difference is surprising, and not all of it can be blamed on the different ways of preservation: continuous manuscript tradition plus papyri versus excavated clay tablets. In the cuneiform texts we hardly find anything that cannot be directly related to musical practice: lists and definitions of dichords, which were apparently at the heart of the instrumentalists' art, sequences of tunings and retuning instructions, classification of songs according to their tuning, finally some musical notation. In the Greek and Hellenistic-Roman world, such types of sources form a small minority or are altogether missing. Of course there are the documents of musical notation, some transmitted from an ancient book, a few found inscribed on stone, the bulk from scraps of papyrus. Apart from these, parts of the compilation known as Bellermann's Anonymus appear to have a strongly practical background, for instance explaining the performance of special notational signs. There must have been practical handbooks for musicians, presumably also for instrument builders, but none of these were further transmitted when the music culture in which they had made sense came to an end. The extant works are of a very different sort: part original treatises furthering 'harmonics' as an abstract science, much as related to music-making; part handbooks for the educated elite, compiling definitions from the meaning of 'music' and 'harmonics' down to the names and mutual relations of scales, perhaps also coupled with a more or less deep-reaching treatment of ratio mathematics. All this mostly for a target audience that was more expected to produce learned statements about music when invited to dinner than to exercise musical skills themselves.

With all its intellectual penetration of pitch structures and philosophical reflection of music's values, then, the rise of Greek science has not protected real music from a certain degree of social demotion. If anything, it has supported an increasing delegation of actual music-making to professionals, upon whose skills – regardless whether those of a trained slave or of an international star – the upper-class citizen could always frown. An intellectual grasp of technicalities, however superficial, thus enabled one to display the status of a 'musical man' (as they had used to call a gentleman in Classical times) without actively engaging in the production of music. The elevation of 'real' harmony to the realm of the inaudible, the cosmos and the well-tuned soul, ultimately paved the way for the rejection at least of instrumental music in upcoming monotheist mainstream doctrine: an ideological task of musical self-discrediting that innocent dichord lists would not have accomplished.